PLATE XXIII.

Figs. 1–4. HALICORNARIA CORNUTA, n. sp.—1. Natural size. 2. Portion of hydrocladium with hydrothecæ, lateral view; magnified. 3. Same, front view. 4. Same, viewed from behind.

5, 6. AGLAOPHENIA LATE-CARINATA, n. sp.—5. Natural size, creeping over a piece of gulf-weed. 6. Portion of main stem with proximal end of a hydrocladium; magnified.

PLATE XXIV.

Figs. 1–4. AGLAOPHENIA DOLICHOCARPA, n. sp.—1. Natural size. 2. Internode of hydrocladium with hydrotheca, lateral view; magnified. 3. Same, front view. 4. Corbula; magnified.

5–7. GATTYA HUMILIS, n. gen. et sp.—5. Natural size, growing over a piece of seaweed. 6. Portion of a colony, showing origin of hydrocladia, from creeping stolon; hydrothecæ seen in profile, with gonangium; magnified. 7. Hydrotheca, front view; magnified.

PLATE XXV.

Figs. 1–3. LYTOCARPUS RAMOSUS, n. sp.—1. Natural size. 2. Portion of a hydrocladium with hydrothecæ; magnified. 3. Portion of a phylactocarp, showing costæ and points from which gonangia arise; magnified.

PLATE XXVI.

Figs. 1–3. PLUMULARIA LAGENIFERA, n. sp.—1. Natural size. 2. Portion of main stem with proximal ends of hydrocladia, and a gonangium; magnified. 3. Portion of a hydrocladium; still further magnified.

4–6. PLUMULARIA MULTINODA, n. sp.—4. Natural size. 5. Portion of main stem with proximal ends of hydrocladia, and a gonangium; magnified. 6. Portion of a hydrocladium; still further magnified.

On the Anatomy of *Sphærotherium*.

By GILBERT C. BOURNE, B.A., New College, Oxford. (Communicated by Prof. MOSELEY, F.R.S., F.L.S.)

[Read 19th November, 1885.]

(PLATES XXVII.–XXIX.)

A SHORT time ago Professor Moseley gave me several specimens of *Sphærotherium*, and pointed out to me the existence of a hitherto undescribed stridulating organ in the males of this genus, to which he refers in the article "Myriapoda" in the 'Encyclopædia Britannica.'

The genus *Sphærotherium* was established by Brandt (Bull.

Nat. Moscou, 1833, p. 200), and has been further described by P. Gervais (Ann. de Sc. Nat. sér. 3, t. ii.), M. Fabre (Ann. de Sc. Nat. sér. 5, t. vii.), Griffith (Animal Kingdom, i. p. 135), and by C. L. Koch (Myriapoden, 1863). More recently Mr. A. G. Butler has contributed largely to our knowledge of the genus ("A Monographic Revision of the Genera *Sphærotherium* and *Zephronia*," Proc. Zool. Soc. Lond. 1873; Ann. & Mag. Nat. Hist. xiv. 1874, p. 185; Trans. Entom. Soc. 1875, p. 165); and Karsch has drawn up a new classification of the group, founded on the differences occurring in the genital orifices of the females ("Zur Formenlehre der pentazonen Myriapoden," Archiv für Naturgeschichte, 1881).

These authors confine themselves principally to a description of the external features of the animals, and to the establishment of specific distinctions. I have not been able to find a full account of the structure and anatomy of the genus. Unfortunately the specimens in my possession, consisting of several individuals, both male and female, of the species *Sphærotherium obtusum* and *S. retusum*, are so badly preserved, that I am unable to give a complete account of their structure; but I have been able to make out a few points which will, I think, be of interest.

The *Sphærotheria* belong to the order Diplopoda, and the family Glomeridæ. Viewed from above, the general shape of the body, when the animal is extended, is that of an ellipse. The dorsal surface is convex, the ventral surface flattened or rather concave. The head, viewed from the front, is subtriangular in shape, and bears a pair of lateral aggregate eyes, beneath which are the deep fossæ in which the antennæ are lodged. The head is succeeded by a small nuchal plate, and this is succeeded by twelve segments.

The tergites of the body are composed of half-rings of very hard and dense chitin connected together by soft skin: when the animal is extended, these overlap one another to a considerable extent. The last tergite is produced laterally and posteriorly, so as to form a complete shield with an evenly rounded thickened margin covering the posterior end of the body. The lateral margins of all the tergites are produced ventrally, and are inclined slightly backwards.

The first tergite is larger than its successor, and its lateral margins (pleura) are produced into strong, backwardly curved processes, which overlap the two succeeding segments. When the animal is rolled up, the head and posterior end of the body

are brought into close apposition, and the spaces that are left along the inrolled margins of the ventral line are completely covered by these processes of the first tergite, rendering the animal quite safe from attack.

The ventral surface is protected by two rows of chitinous plates on each side. These are figured and shortly described by Brandt (*loc. cit.*). Corresponding to each of the tergites, except the first, is a ventro-lateral plate roughly quadrilateral in form, with the angles rounded off. There are thus eleven of these plates on each side of the body; and they are set nearly at right angles to the pleura of the tergites, which project some way beyond them ventrally. Interiorly to the ventro-lateral plates is a row of twenty-one smaller chitinous plates, on each of which is a tracheal opening. They may be called the *tracheal plates*. Of these, the first three belong to the first three segments of the body. The remaining nine segments have a pair of tracheal plates on each side.

There are twenty-four pairs of appendages in the female and twenty-seven pairs in the male *Sphærotherium*. The antennæ are sunk in deep fossæ on the sides of the head, at once distinguishing this genus from *Glomeris*. They are six-jointed; the terminal joint is truncated and bears a terminal sense-organ, which I shall describe in detail further on. Brandt speaks of seven joints; from his figures it appears that he has counted the plate on which the sense-organ is placed as a seventh joint.

The mandibles are two-jointed, and are typically those of a Diplopod. As in all other Diplopoda, the maxillæ are fused together to form a broad plate behind the mandibles.

There are twenty-one pairs of walking-legs in both the male and female *Sphærotherium*. The first three segments behind the head bear one pair of legs each. The remaining nine segments each bear two pairs of legs. The legs are six-jointed, the terminal joint bearing a small claw. They are well figured by Brandt. The genital openings of both the male and female are on the basal joint of the second pair of legs. An account of these openings and the chitinous valves surrounding them is given by Karsch (*loc. cit.*), who considers them to be of systematic value. No external organs of copulation are connected with the male openings.

In the female the twenty-first pair of legs is succeeded by the anus, which is guarded by a pair of lateral chitinous valves.

In the male three pairs of accessory copulatory appendages are inserted between the twenty-first pair of walking-legs and the anus. Although these appendages have been described by Fabre, and more fully by Karsch, these authors have overlooked several points of importance connected with them.

These three pairs of appendages in the male are clearly accessory appendages developed in connexion with sexual functions, and have no connexion with the segmentation. Whereas each pair of walking-legs has a ganglion developed on the ventral nerve-cord in connexion with it, the copulatory appendages have no ganglia proper to themselves, but are innervated from the twenty-first ganglion (see fig. 14) of the ventral chain; and whilst a pair of tracheal openings corresponds with each pair of walking-legs, there are no tracheæ in connexion with the copulatory appendages.

The first pair of copulatory appendages is small, and each limb is three-jointed. The first joint is small, and flattened from side to side. The second joint is the largest of the three, and posteriorly is produced into a claw-like process. The third joint is hinged upon the base of this process, and closes upon it to form a chela. In this way a simple pair of weak pincers is formed in *S. retusum*; but in *S. obtusum* the chela is modified to form what I believe to be an accessory stridulating organ. A hood-like projection is developed from the third joint (fig. 2, a^1), with its concavity turned towards the claw-like process of the second joint. The interior concave side of this hood-like process bears a number of parallel ridges which work against the claw of the second joint, and in so doing produce a slight grating sound. The articulation between the second and third joints is of such a kind that they do not act together as pincers; but only a lateral motion of the third joint across the claw of the second is possible, whereby the stridulation above referred to is effected.

The second pair of accessory appendages is much stouter than the first; as in them, each limb is three-jointed, and the second and third joints together form a strong pair of pincers, called by Fabre the *forcipules copulatrices*. The shape of these chelæ differs somewhat according to the species; and hence they are of specific value. Fig. 3 is a representation of the chelæ of *S. obtusum*, and figs. 5 and 6 represent those of *S. retusum*.

Although Karsch has described these appendages somewhat minutely, and has given figures of their forms in different spe-

cies, he has unaccountably overlooked the well-defined stridulating-organ developed in connexion with them. This organ is similar in the two species which I have examined, and consists of a prominent bolster-shaped swelling on the postero-external edge of the second joint. This swelling occupies the entire exterior margin of the joint, and shows a number of transverse parallel ridges separated from one another by concave furrows. The whole organ is more darkly pigmented than the adjoining parts, and the crest of each ridge is occupied by a line of nearly black and exceedingly hard chitin. Opposite to this rasp-like organ, on each side, the interior surface of the last tergite is slightly raised into a cushion-like projection, which projection is armed with a number of hard stiff chitinous points. By rapidly rubbing the rasp-like organ on the second pair of accessory appendages against the roughened interior surface of the last tergite, I succeeded in producing a tolerably shrill note, not unlike that of the common house-cricket. There can be no doubt that this is a stridulating apparatus used by the males to attract the females.

The male *Sphærotherium* probably rasps his limb against his tergite a great deal faster than I was able to do, and produces a shrill high-pitched note. As far as I know, nobody has given an account of any stridulation produced by the males of this genus. It would be interesting if any naturalist proceeding to, or living at, the Cape were to observe the habits of the *Sphærotheria*, and give us some account of the stridulation which is doubtless produced by the males.

Observations on the mode of copulation would also be of interest.

The third pair of accessory organs consists of two spike-shaped single-jointed appendages lying between and rather posteriorly to the *forcipules copulatrices*. These I believe to be penes. They are perforated at their extremities, and contain a central cavity; but I was not able to detect any spermatozoa or spermatophores in the latter. When the animal is rolled up they are capable of being applied to the generative openings on the second pair of limbs; but there is no internal communication with the gonads. Until the act of copulation in *Sphærotherium* has been observed, it is not possible to say whether these appendages function as penes or not; but from their position and structure, and from the fact that no other copulatory organs exist in the male *Sphærotheria*, whereas such are present in the allied genus *Glomeris*, I think it highly probable that they do.

The vascular system, alimentary tract, gonads, and genital ducts were so badly preserved in my specimens as not to admit of accurate investigation; but so far as I was able to investigate them, they do not depart in any important particulars from the structure characteristic of the Julidæ. The alimentary tract is bent once upon itself, as in *Glomeris*.

The tracheal system, however, is quite unlike that of the majority of the Diplopoda. In them, as is well known, the stigmata open into as many dilated vesicles, from each of which a tuft of short unbranched tracheal stems, having a very feebly developed spiral filament, are given off. In *Sphærotherium* the tracheal stems are stout, have a well-developed spiral filament, and are much ramified, in this respect resembling those of the Chilopoda and Insecta; but they differ from these in taking their origin, not directly from the stigmata, but from peculiar sac-like cavities, with firm chitinous walls, into which the stigmata open. These internal chitinous structures, which I shall call tracheal sacs, occur in connexion with each pair of walking-legs. A single tracheal sac, with its tracheal plate attached, is represented in fig. 8. It is triangular in outline, somewhat compressed from side to side; and its walls are composed of firm but translucent chitin. At one of its angles it is attached to the tracheal plate, and opens through it to the exterior by an oblique slit-like stigma. From its other two angles stout tracheæ are given off. Each tracheal sac lies with its longest axis at right angles to the long axis of the body of the animal. The tracheæ springing from its innermost angle, near to the median line, are distributed to the viscera; those springing from its outermost or distal angle supply the powerful lateral and dorsal muscles of the body. Three stout tracheæ, springing from the first pair of tracheal sacs, are distributed to each side of the head.

The tracheal sacs and their stigmata have precisely the same relation to the segmentation of the body as have the walking-legs. Thus each of the first three body-segments has one pair of tracheal sacs, the remaining nine segments two pairs each, making twenty-one pairs in all. A diagram of the tracheal sacs and their relations is given in fig. 8.

Glomeris, which is in all its characters closely allied to *Sphærotherium*, is also distinguished by the presence of branched tracheæ (Gegenbaur's Comp. Anat., English edit. p. 288); and the same is doubtless the case in the allied genus *Zephronia*.

But beyond the bare mention of the fact in the work above quoted, I have not found a description of their tracheæ in any other author; and the differences in the tracheæ are generally considered to rank among the leading distinctions between the Diplopoda and Chilopoda.

It seems that the tracheæ of *Sphærotherium* are a transition from those of the *Julus* type to those of the *Scolopendra* type. I do not, however, infer that any genetic relationship exists between *Sphærotherium* and the Chilopoda. The whole anatomy of the former points to its being a highly specialized Diplopod, in which, in accordance with its high specialization, the tracheal system has become more fully developed than in the other members of the group to which it belongs; and the development has been in the same direction as in the Chilopoda and Insecta. The resemblance in fact is due to homoplasy, not to homology.

The tracheæ of *Sphærotherium* may be derived from those of *Julus* and *Peripatus*; and the tracheal sacs are, no doubt, homologous with the tracheal sacs in both these forms. The presence of the tracheal sac is a primitive character which is found only in the Prototracheata and Diplopoda. In *Sphærotherium* the primitive character of the sacs is altered in so far that the tracheal stems are no longer given off as a tuft from the surface of the tracheal sac, but two primary stems are given off, one from the dorsal part of the sac lying nearest to the median line, the other from the extreme lateral prolongation of the sac, with which the tracheal stem appears to be continuous. The primary stems soon branch; both they and their branches have well-developed spiral filaments, and their ultimate ramifications extend through all the tissues of the body.

It may be observed that in *Sphærotherium* the openings of the tracheal sacs on the surface of the body are clearly the *stigmata*, and not the openings of the tracheæ into the tracheal sacs. This is worth mentioning, because a writer on *Peripatus* has denied that the sac-mouths are the true stigmata, and has confined that name to the openings of the unbranched tracheæ into the sacs (Gaffron, "Beiträge zur Anat. und Histologie von *Peripatus*," Zool. Beiträge von A. Schneider). He regards the latter simply as invaginations of the skin; but the tracheæ themselves are nothing more than invaginations of the skin modified for respiratory purposes; and it is better to regard the tracheal sacs as an integral part of the tracheal system, and the sac-mouths as the true stigmata.

As is shown in my diagram (fig. 14), there is a complete correspondence between the walking-legs, the stigmata, and the ganglia of the ventral nerve-cord; and these structures occur twice in every segment after the third. I have not yet seen a satisfactory explanation of this double segmentation in the hinder region of the bodies of the Diplopoda; nor am I able to offer one myself, though I have given much thought to the subject. Until we arrive at a satisfactory solution of the origin of metameric segmentation itself, it will scarcely be possible to explain this additional complication which has been grafted on it.

The nervous system is quite similar to that of *Glomeris*, which is described by Leydig (Tafeln zur vergleichenden Anatomie: erstes Heft, Taf. vii. figs. 3 & 5). As stated above, there is a small ganglion on the ventral nerve-cord corresponding with each pair of legs. From each ganglion a pair of nerves is given off to the legs, and a pair of nerves runs outwards dorsally to the tracheal sacs. The accessory appendages of the male derive their nerve-supply from the last ganglion of the ventral chain.

The eyes are aggregate, each being formed of a group of closely apposed simple eyes. Those of my specimens were unfit for microscopical examination.

The antennary sense-organ is especially well developed in *Sphærotherium*. Leydig was the first to call attention to the existence of terminal sense-organs on the antennæ of *Julus*; and in his figures of the nervous system of *Glomeris* (*loc. cit.*) he draws the nerve-endings on the antennæ of that genus.

Although these antennary sense-organs are conspicuous, their histological structure was not described until Bütschli gave a short account of them in the 'Biologisches Centralblatt,' No. IV. 1884, p. 113. He gives a woodcut of the structure of the sense-organ of *Glomeris*; but his account and his figure are mostly from memory, and he does not pretend to very great exactness.

In *Sphærotherium* the terminal joint of the antenna is truncated, and the truncated surface is covered with a thin flat plate of chitin. On the surface of this plate stand up a number of conical or spike-like chitinous projections, each being surrounded by a white ring with a dark pigmented border. In the antenna which I have figured (figs. 9 & 10) there are eighteen such projections; but the number is not constant, varying from fifteen to twenty. Their number is much less in the Julidæ: in a

large *Spirobolus* from Ceylon I found four; and in different species of *Julus* only two or three. These projections are little conical caps of chitin perforated at their extremities, and containing the terminal nerve-fibres of the organ of sense. It was very difficult to obtain good sections of this organ. The only method was to imbed the antenna in paraffin and then to cut close round it and pick away the chitin bit by bit, afterwards re-embedding the soft parts, and cutting a series of sections in the ordinary way. The antennæ of my specimens being small as compared with the bulk of the body, were better preserved and fit for histological purposes.

The antennary nerve breaks up in the penultimate joint into as many branches as there are nerve-endings on the terminal joint, and each branch is continued into a spindle-shaped bundle of nervous tissue which lies in the terminal joint. Thus there are a number of these bundles lying side by side in the terminal joint of the antenna, and each mass lies directly underneath, and is continued into one of the conical projections described above.

Each bundle of nerve-fibres, as it passes into a spindle-shaped body, breaks up into a number of branching and anastomosing nerve-fibrils, forming a *neurospongium*. From the neurospongium proceeds a bundle of nerve-fibres, which are beset in their course with a number of ganglion-cells. These cells are nucleated, and lie along the nerve-fibres so as to give the appearance of regularly arranged parallel linear series of cells (see figs. 11 and 12). The nervous bundles are thickest in the region of these nerve-cells; beyond them the bundle tapers away somewhat rapidly, and consists of closely-packed fine nerve-fibres which run up towards the conical projections on the end of the antenna, and enter into close connexion with the bases of the fine sense-hairs, which protrude slightly through these projections. The bundles are isolated from one another by connective tissue, and fine tracheal branches run between them right up to the end of the antenna.

Lying among the branched connective tissue-cells and surrounding the proximal ends of the nervous bundles are a number of large oval cells, each with a distinct oval nucleus, which stains deeply with hæmatoxylin or borax-carmine. Whatever the nature of these cells may be, they are certainly not ganglion-cells, and give off no processes continuous with the nerve-fibres (fig. 12, *c*).

Bütschli describes a proximal set of large nucleated *ganglion-cells*, and a distal series of smaller *sense-cells* as occurring in each bundle. It is evident from his figures that the cells which he calls true sense-cells correspond with those which I have described as ganglion-cells; whilst he has taken the large oval nucleated cells referred to above to be ganglion-cells occurring in the proximal end of the sense-organ. But the cells in question lie outside the nervous bundles, among the connective tissue which surrounds them; they have not the structure of ganglion-cells, and are found in all parts of the antenna, and are by no means confined to a zone surrounding the proximal ends of the nervous masses in the terminal joint. In the proximal part of the antenna these cells are confined to definite spaces in the connective tissue, and I believe that they are nothing more than blood-corpuscles, which would be amœboid in the living state, but have assumed an irregularly oval shape under the action of spirit. Definite lacunar channels appear to lead through the antenna, and to open into relatively large lacunar spaces which surround the proximal ends of the nervous masses in the last joint. Hence in spirit specimens one finds a mass of blood-corpuscles aggregated round the nerve-masses, and more particularly around that part which I have described as being a neurospongium. In thick longitudinal sections these cells appear to form part of the nerve-substance; but in thin sections and in transverse section (fig. 13) they are easily seen to be quite distinct from it.

No doubt, as Bütschli says, the antennary organs of the Diplopoda are comparable with those of *Peripatus* on the one hand (see F. M. Balfour, "Anat. and Devel. of *Peripatus capensis*," Quarterly Journ. Micr. Science, 1883, p. 213), and with those of *Vespa Crabro* and other insects on the other (see Häuser, "Geruchsorgan in Insecten," Zeits. f. Wiss. Zool. xxxiv. p. 367). Häuser adduces physiological proof of the olfactory function of these organs in insects; but without definite proof I should hesitate to attribute the same function to the organs of Diplopods, and prefer to call them simply "antennary organs."

It is commonly stated that there are no auditory organs in Myriapoda, but the existence of a stridulating organ in the male *Sphærotherium* postulates the existence of an auditory organ, in the female at any rate. Leydig, in his 'Tafeln zur vergleichenden Anatomie' (erstes Heft, Taf. vii. figs. 3 and 5), figures what he calls an "eigenthümliches Sinnesorgan" occurring on the

head of *Glomeris marginata*. This is a horseshoe-shaped organ lying beneath the eye on either side of the head, and supplied by a special nerve coming from the hinder part of the cerebral ganglion. In the description of the plates he gives the following account of it:—". . . besteht aus einer hufeisenförmig Vertiefung der Haut, von beiden Seiten durch vorspringende Ränder bis auf eine schmale Spalte geschlossen. . . . Von Boden erhebt sich ebenfalls ein hufeisenförmig gebogener Wulst. Derselbe dient zur Aufnahme einer gangliösen Nervenendigung."

Lying within the antennary fossa, just beneath the eye, in *Sphærotherium*, is a small round opening, surrounded by a thickened rim of darkly pigmented chitin. This opening leads into a small cavity, which seems to be lined with sensory epithelium, and to be a sense-organ corresponding to the horseshoe-shaped organ described by Leydig in *Glomeris*. This organ is supplied, as in *Glomeris*, by a nerve springing from the hinder part of the cerebral ganglion. The organ is enclosed between two plates of exceedingly dense chitin, meeting at an acute angle to form a ledge projecting over the antennary fossa, and all my attempts to cut sections of it, or to make a preparation fit for microscopical examination, failed. I tried several times, but unsuccessfully, to dissect out the organ from the chitin that surrounds it.

I must therefore confine myself to pointing out the position of the organ, and its homology with Leydig's organ in *Glomeris*. My conviction is that these are true auditory organs.

Unfortunately, as I am soon leaving England, I have not had time to obtain living specimens of *Glomeris* and investigate Leydig's organ with a view to determining its function. It will not be out of place here to call attention to the fact that one of the Chilopoda is known to stridulate *. The fact that this chilopod does stridulate points to the existence of an auditory organ in at

* Gerstäcker (Stettin. Entom. Zeit. 1854, p. 312, Taf. ii. fig. 1) describes in *Eucorybas crotalus*, a chilopod, a sound-producing apparatus: the hindermost pair of legs have their fourth joints much enlarged and leaf-like, with their edges raised and formed of hard chitin. When moving, and especially when excited, these two laminar appendages are rubbed against one another and thereby produce a rasping sound. It is curious to observe further that the third joint on the inner side is produced into a process, and forms, with the fourth joint, a weak pincer-like apparatus, though Gerstäcker does not state that it has any such use. *Eucorybas* is also a South-African myriapod, being found at Port Natal.

least one member of the group, and I have no doubt that a closer investigation will show that it is of general occurrence.

The character of the trachea, the curved alimentary tract, the numerous chitinous pieces composing each segment, and the presence of a special sense-organ on the head, mark off the family Glomeridæ, to which *Sphærotherium* belongs, very sharply from the other families of the Diplopoda.

In conclusion I must express my thanks to Professor Moseley, who kindly gave me the specimens with which I have worked, and assisted me in many other ways.

I am also much indebted to my friend Mr. W. Baldwin Spencer, who has kindly undertaken to see my work through the press during my absence from England.

EXPLANATION OF THE PLATES.

Plate XXVII.

Fig. 1. Lateral view of a large specimen of *Sphærotherium obtusum*, nat. size.

2. *S. obtusum.* Left first accessory appendage of the male, viewed from behind. 1, proximal joint; 2, middle joint; 3, distal joint. *p.* Claw-like process of middle joint at the base of which the distal joint is articulated, thus forming a chela. *a.* Hood-like process on distal joint. a^1. Parallel ridges on *a* which work against the process *p*, thus forming a stridulating organ.

3. Second pair of accessory appendages of *S. obtusum*, ♂. 1, 2, 3. The three joints of the appendage. *f.* The *forcipules copulatrices* (Fabre) formed by the middle and distal joints. *a.* Stridulating organ. *b.* Penes.

4. Stridulating organ on the second accessory appendage of *Sphærotherium*, much magnified.

5. Accessory appendages of *S. retusum*, ♂, viewed from behind. 1, 2, 3. Joints of second accessory appendage. *f. Forcipules copulatrices.* *a.* Stridulating organ.

6. The same viewed from in front. I. & II. The first and second accessory appendages. 1, 2, 3. Joints of second appendage. *f. Forcipules copulatrices.* *a.* Stridulating organ. *p.* Penes.

7. The last shield-shaped tergite of *S. obtusum.* *a.* External surface. *b.* Concave internal surface. *c.* Thickened and produced inferior margin. *d.* The rasp-like stridulating cushion developed on the internal surface and against which the stridulating organ (fig. 4, and *a*, figs. 3, 5, 6) works.

8. Single tracheal sac of *S. obtusum*, viewed from the inner side, and attached to its tracheal plate. *a.* Tracheal sac. a^1. Angle of the sac which is attached to the tracheal plate (*c*). a^2, a^2. The two angles of the sac from which spring the tracheal tubes (*d*, *d*). *b.* Stigma, opening into the tracheal sac at the angle a^1.

Fig. 9. Antenna of *S. retusum*, showing the terminal sense-organ. *p*. The processes in which are the sensory hairs. *r*, *r*. The white ring surrounding each process.

Plate XXVIII.

Fig. 10. A still further enlarged view of the end of the antenna of *S. retusum*, showing the sense-organ: the lettering as in fig. 9, Pl. XXVII.

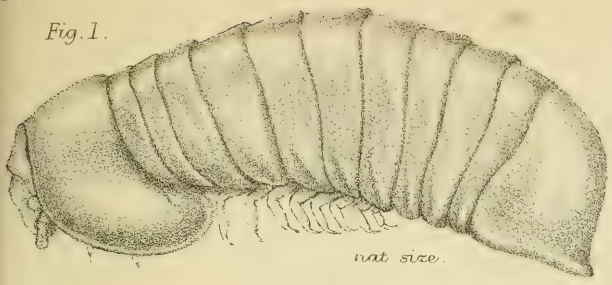
11. Diagrammatic longitudinal section of the antennary organ in *S. retusum*. *a*. Antennary nerve. a^1, a^1, a^1. The branches of the nerve, one going to each nerve ending in the terminal point. a^2, a^2. Nerve-bundles formed of neurospongium. *c*. Large ovoid cells (blood-corpuscles?) lying in the connective tissue (*t*) which surrounds the nerve-bundles. *g*. Ganglion-cells. *e*. Terminal sense-organs.

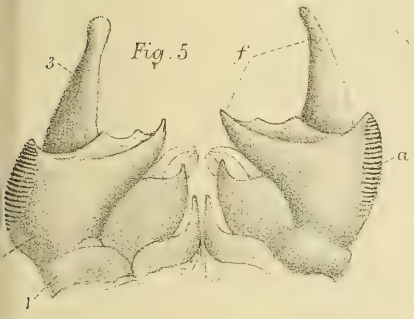
12. A single nerve-bundle, much magnified. a^1. Branch of antennary nerve. a^2. Neurospongium. *g*. Ganglion-cells. *s.h.* Sensory hairs surrounded by a chitinous cap (*c.h.*). *t*. Connective tissue. *tr*. Tracheæ. *c*. Large ovoid cells (blood-corpuscles?).

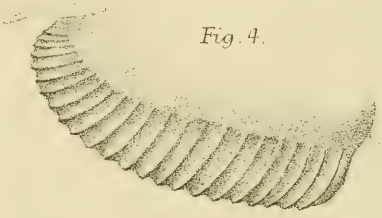
13. Diagrammatic transverse section through the antennary organ, much magnified. *b*. Nerve bundles in section. *c*. Large ovoid cells (blood-corpuscles?). *s.c.* Subcuticular layer of cells. *p*. Pigment.

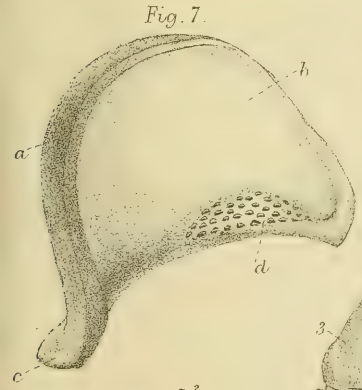
Plate XXIX.

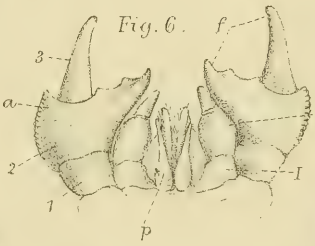
Fig. 14. Diagram of the tracheal and nervous system of *S. obtusum*. *a*. Antenna. *an*. Antennary nerve. *au*. Auditory (?) nerve. *cb*. Cerebral ganglion. *co*. Nerve-commissure. co^1 and co^2. Nerves joining the two strands of the commissure above and below the œsophagus. *e*. Eye. *g* 1, *g* 2, *g* 3. The ganglia of the three first body-segments. *g* 6, *g* 9. The pairs of ganglia belonging respectively to the sixth and ninth body-segments. *g* 21. The last ganglion, being the hinder one of the pair belonging to the twelfth segment. *n*. Nerve arising from the last ganglion, and supplying the accessory appendages of the male. n^1, n^1. Larger nerves to the appendages. n^2. Smaller nerve to the penes. *n.l.* Nerve supplying the leg; one pair arises from each ganglion. *n.t.* Nerve to the tracheal sac, one pair arising from each ganglion. *o*. Optic nerve. *œ*. Œsophagus cut through. *sn*. The sense-organ on the terminal antennary joint. t^1. Tracheæ, arising from the tracheal sac near the middle line, and supplying the viscera. t^2. Tracheæ arising from the tracheal sac near the lateral line on either side and supplying the dorsal and lateral muscles. t^3. Three large tracheæ arising from the first tracheal sac and supplying the head. *t* 21. The last tracheal sac, being the hinder one of the pair belonging to the twelfth body-segment. 1, 2, 3. The single tracheal sacs in the first three body-segments. 4, 5, 6, 7, 8, 9, 10, 11, 12. The pairs of tracheal sacs belonging to the nine posterior body-segments.

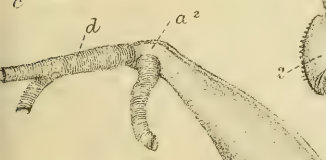


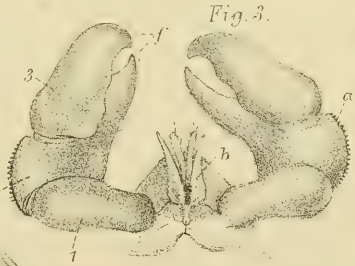


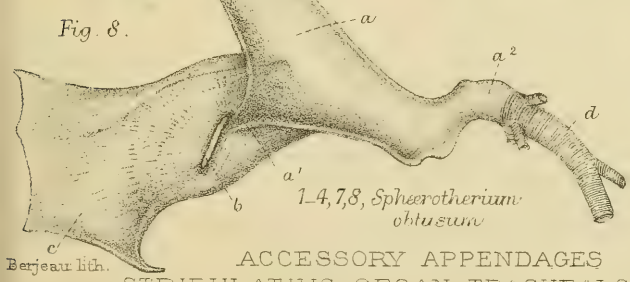












1–4,7,8, *Spherotherium obtusum*

5,6,9, *S. retusum*.

Berjeau lith. ACCESSORY APPENDAGES STRIDULATING ORGAN, TRACHEAL SAC &c. Mintern imp.

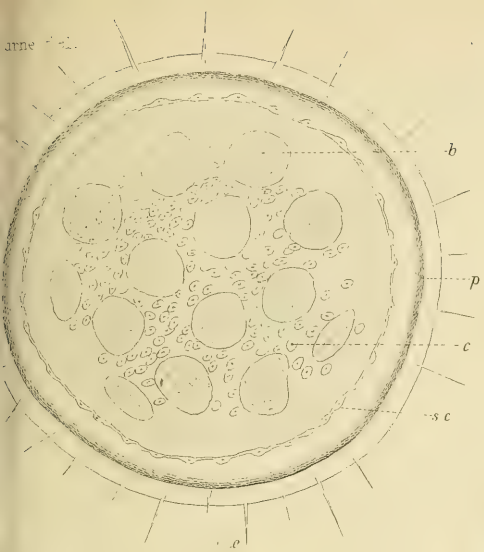
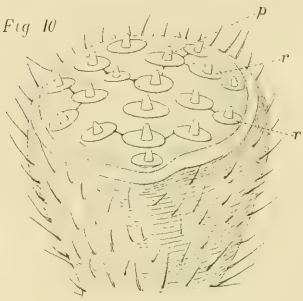


Fig 10



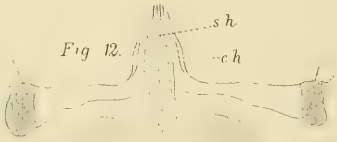


Fig 12.

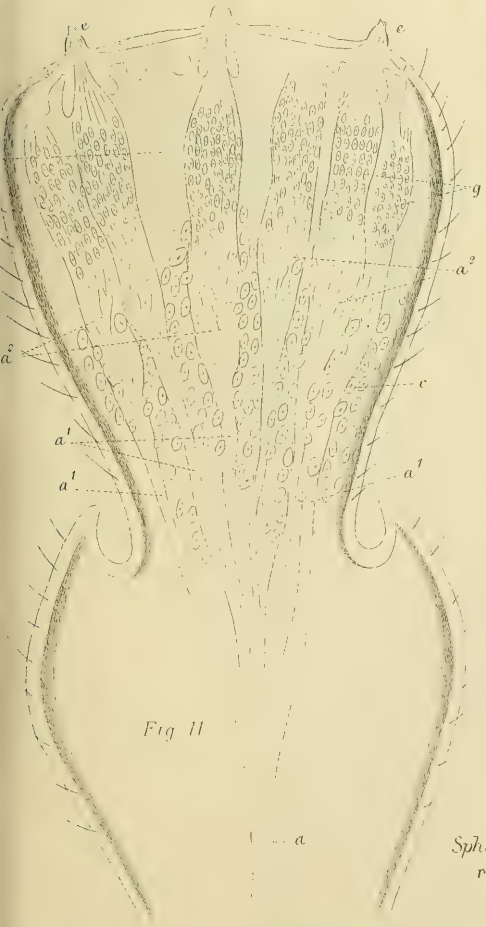
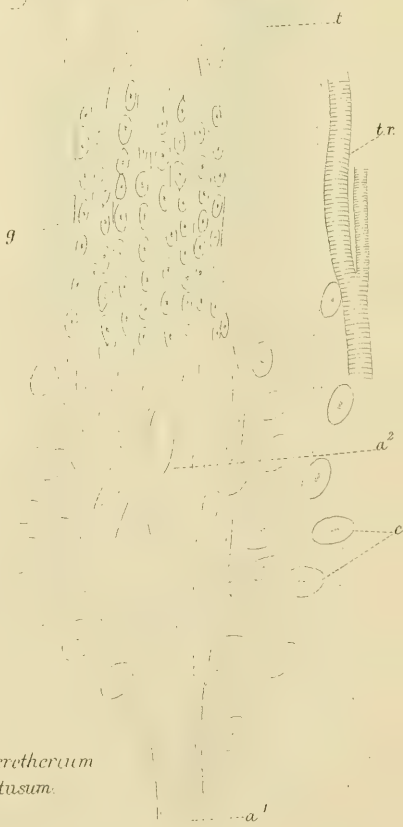
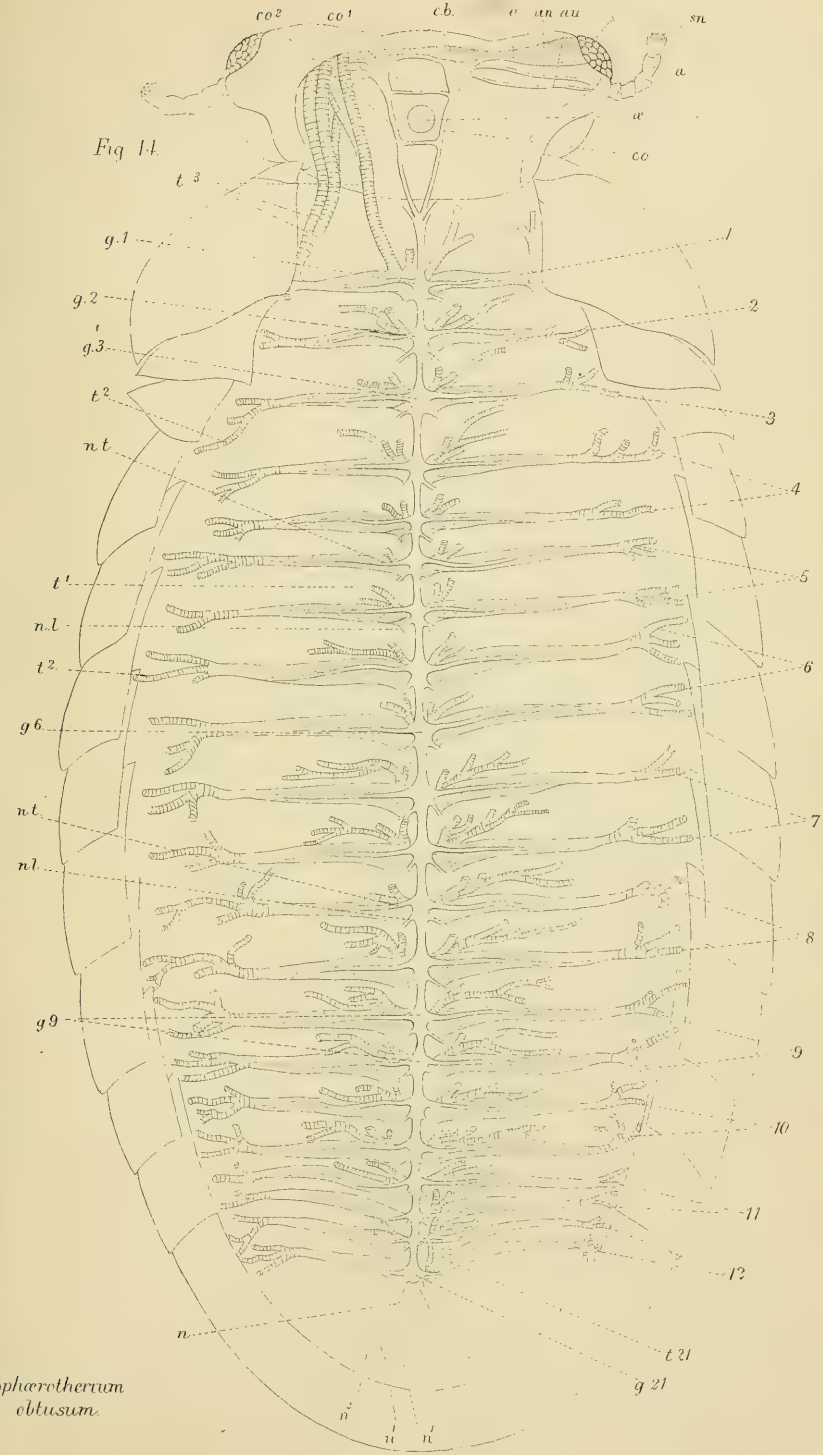


Fig 11



Sphærotherium retusum.



Sphærotherium obtusum